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STRUCTURAL REINFORCEMENT SYSTEM FOR REINFORCING OPENINGS FORMED IN STRUCTURES

CLAIM OF PRIORITY

The present application is a continuation in part of U.S. Patent Application No. 09/497,414 filed February 2, 2000, now, U.S. Patent No. __,______, which was a continuation in part of U.S. Patent Application No. 09/257,875 filed February 25, 1999 now, U.S. Patent No. 6,192,637, the entireties of each of which are herein incorporated by reference.

FIELD OF THE PRESENT INVENTION

The present invention relates generally to structural support systems. Particularly, the invention relates to a structural reinforcement system for a building. More particularly, the present invention relates to a structural reinforcement system configured to reinforce openings formed in a structure.

BACKGROUND OF THE INVENTION

Damage caused by seismic and hurricane force events have exposed the need for improved force-resisting structural reinforcement for both new building structures and for retrofit into existing building structures. As utilized herein the term "retrofit" is to be understood to include remodeling, reconstruction, strengthening, shearwall fabrication, or similar construction processes.

All building structures must be designed to safely resist loads that may be applied thereto. Such forces include seismic load, wind load, dead load (the structure's weight), and

other forces. Total lateral loads are primarily resisted through the walls of the structure that have their planes parallel to the loading direction via in-plane (lateral) shear. In addition to these shear forces, seismic activity will apply "uplift" and "overturning" forces to the structure. The vertical pulling (uplift) forces occur when the lateral forces attempt to rotate the walls of the structure about a corner of the structure (overturning). The structure must be designed to have sufficient "shear resistance" so that the structure does not sustain cumulative damage from repeated exposure to minor loading events; or excessive damage or collapse due to higher loading events; potentially resulting in extensive financial cost, serious injury or loss of life. Shear resistance can be further defined as the ability of the structure to absorb, dissipate and transfer forces.

A "shear force" as used herein describes a force that is transmitted through the plane of a wall. This can be better understood with reference to FIGURE 1. As shown conceptually in FIGURE 1, a shear force V1 applied to a wall will result in the force being reacted at the boundaries of the wall, with the relative shear reaction contributions V2, V3, and V4 and tension-compression reactions A1-A8 depending on wall and adjacent structure configuration and stiffness all of which may be non-uniformly distributed. A properly constructed shearwall will not undergo excessive deflection as shown by the solid lines in FIGURE 1. In the case of an improperly constructed or otherwise inadequate shearwall, the shearwall will deflect as shown by the dotted lines in FIGURE 1; this can cause excessive damage or failure of the structure.

A common cause of structural failure occurs due to a drastic difference of lateral shear stiffness characteristics between two adjacent stories of a building design. A softstory is a

story in which the lateral stiffness is less than 70 percent of that in the story above. In the case where a softstory exists within a building (as shown in Figure 5) and a load is applied, the softstory is in series with the upper floor(s) and must carry all the building load because the load path to the upper floor(s) is soft and/or weak . Most of the stresses due to forces that are applied to the structure will concentrate within the softstory or immediately adjacent portions of the structure and will also result in twisting of the structure leading to additional torsional stresses and other stress amplifications; this can cause excessive damage or failure of the structure.

It is well known that in building construction and design, the engineer/architect must incorporate every structural element to work together as an interconnected system in order to provide a continuous load path to absorb, dissipate and transmit applied loads through the structure into the foundation. It is important that every structural element within the system has the necessary strength and stiffness properties in order to share the applied loads. If every structural element does not work together, this may lead to excessive damage or failure of a structural element due to force over-loading of the structural element, as opposed to load sharing. For example, if one structural element is constructed as being stronger/stiffer than the adjacent structural elements, the stronger/stiffer structural element will carry the significant portion of the applied load. If the stronger/stiffer element cannot support this load concentration then the stronger/stiffer structural element may fail due to overloading prior to receiving any significant load carrying contribution from the adjacent structural elements. Alternatively, if the element is not strong/stiff enough, the adjacent portions of the structure may sustain damage before the soft portion can carry any significant portion of the loads. In addition, irregular placement of structural elements with varying strength/stiffness characteristics can result in twisting of the structure leading to additional torsional stresses

and other stress amplifications. Therefore, in order for a structural reinforcement system to be effectively integrated into a building, the placement and the strength/stiffness characteristics of the structural reinforcement system must be considered in order for it to function in cooperation with the existing structure when the structure is subjected to a force.

A general construction method of providing shear resistance is through the use of wood paneled shear walls, which are vertical diaphragms that are built on-site. A typical shearwall is constructed including: a sill plate, a plurality of vertically extending members, a top plate, and sheathing material extending between the top plate and the bottom plate attached to the plurality of vertically extending members. The sheathing material may be comprised of wood structural panels such as plywood or oriented strand board (OSB). It shall be understood that other sheathing materials may be utilized, those described above are to be considered exemplary and not limiting. In constructing shear walls, specific anchoring and nailing schedules must be followed. The shear walls must be anchored to a foundation utilizing specialized anchors installed in the foundation and disposed through the sill plate; the anchors are spaced apart at a predetermined distance and resist sliding (shear) and overturning forces. Furthermore, the vertical members of the shearwall may be anchored to the foundation using hold-downs in order to resist overturning forces. In addition to anchoring the sill plate to the foundation, the header must be attached to the roof structure or if appropriate to the floor joists of a second story. The header is typically attached utilizing specialized connectors configured to provide seismic reinforcement. Though, in many cases the installation of these specialized fasteners as well as the overall general construction of the shearwall may not be done properly. Following the 1994 Northridge earthquake, it was discovered that a large percentage of building failures occurred as a result of poor field construction practice. One such study indicated that one third of the seismic safety items

installed during construction were missing/improperly installed or poorly implemented in over 40% of the structures surveyed.

In addition to resisting lateral forces, a shearwall must also restrain uplift or overturning of the structure. Generally, shear walls are constructed having a specific aspect ratio, which is a height to width ratio. The overturning moment, for a given shear load, is proportional to the shearwall height. The aspect ratio of a shearwall affects how much "uplift force" is generated by reaction of the shear force applied to the building. The uplift corner force (such as A2 in Figure 1) is proportional to the aspect ratio. An example of a high aspect ratio shear panel is a sidewall next to a large opening such as a garage door opening. In fact, the Uniform Building Code (UBC) allows a maximum 2:1 aspect ratio on shear panels adjacent to an opening. It will be appreciated that by joining the adjacent sidewalls together with a lateral force resisting system, the effective aspect ratio of the resultant shear structure would be greatly reduced, thereby reducing the uplift forces resulting from the shear loads.

When considering a single shearwall, there are multiple components, and therefore multiple parallel load paths, to carry applied loads. An ideal shearwall is one that does not contain any interruptions or load path discontinuities therein. Common interruptions or load path discontinuities that may be formed in shear walls are window or door openings. Specifically, the openings create interruptions in the force absorbing/dissipating/transmitting function of the shearwall. Therefore, in designing a structure the number, placement, and size of openings formed in the shear walls must be limited or compensated for without causing load concentrations in the remaining structure. Openings formed in a shearwall reduce its overall shear resistance capacity. Therefore, it is a common practice to “over-build” by adding strength/stiffness to the shear panels adjacent to the openings to compensate for the

reduced shear resistance. Over-building of shear panels is not a desirable solution as described above because by making the shear panels stronger/stiffer than other portions of the wall will cause most of the forces to concentrate within the stronger/stiffer panels. This is undesirable, because as described above, the structure should be designed wherein all of the components of a shearwall share the loads applied to the structure equally. For a more detailed explanation of force transfer within a shearwall see Wood Engineering and Construction Handbook, Third Edition, Keith F. Fahert and Thomas G. Williamson, McGraw-Hill 1999, Chapter 8.

In addition to the considerations that must be applied to new construction, as described above, even more detailed consideration must be made when retrofitting an existing structure. Many times when retrofitting an existing structure it is found that the structure was built wherein a softstory condition exists; without sufficient reinforcement for earthquake resistance; or more specifically having severely inadequate lateral and uplift reinforcement. As mentioned above, even if the structure was constructed having taken into account modern code requirements, it is common to find that many reinforcement devices and nailing schedules were not applied properly during construction of the structure. Therefore, before reinforcing existing openings or forming additional openings within an existing wall, the wall must be inspected carefully for proper construction and most often improved through structural retrofitting. Furthermore, during a remodel if a window opening is formed within a shearwall where an opening did not previously exist it is likely that the opening formed will cause the shearwall to become too soft, thereby reducing the shear wall's required load-sharing capacity; potentially resulting in excessive damage or failure of the building.

There have been several attempts at strengthening shear walls adjacent to openings and addressing the issue of improper field installation of structural reinforcement devices. One such product is known as the "Hardy Frame" produced by Simplified Structural Systems, 1660 E. Main St., Ventura, CA 93001. The "Hardy Frame" was designed in response to the damage caused by the 1994 Northridge Earthquake. The Hardy Frame is an engineered light gauge steel frame connected to bolts embedded into a concrete foundation. The Hardy frame is designed to resist earthquake and wind loads. The frame delivers a given amount of resistance to shear loads and up-lift loads depending upon the size and model of frame utilized. The installation of a Hardy Frame is performed in multiple stages, the first stage is the concrete foundation stage, a template including a number of bolts and spacers is utilized to space and hold the fasteners on the foundation framework. After the foundation has cured, the template is removed and the Hardy Frame is installed during the building process. The bottom of the Hardy frame is attached directly to the foundation with the bolts disposed in the foundation in step one. The top of the frame is attached to the top plate or header utilizing a plurality of fasteners such as screws. In addition the outer surface of the frame must be attached to the header or top plate with a strap connector or similar device. In addition to being installed in single story applications, the Hardy frame is also approved for installation on the second floor of a two-story structure. The frame must be installed having a distance of at least three inches from any king stud, a king stud is defined as the stud that defines the vertical portion of a door or window opening, however six inches of clearance is recommended. Further still the minimum width of any Hardy Frame is eighteen inches, coupled with six inches on either side requires a total of thirty inches between window or door openings. However, in many modern structures it is desirable to place door and window openings closer together than thirty inches. Another shortcoming of the Hardy Frame is that it is designed for new construction and cannot be readily or economically applied to retrofit

applications. In order to utilize the Hardy Frame in a retrofit application; wall framing, sheathings, and coverings would require costly removal and replacement. The foundation must also be carefully inspected, drilled and/or cut away and re-poured so that the bolts needed to hold the Hardy Frame to the foundation can be disposed therein, which renders the installation highly vulnerable to installation errors and foundation material degradation. Further, there must be a sufficient amount of room on either side of the openings in order to install the frame as described above. Lastly, and the most important shortcoming of the Hardy Frame is that the frame in many instances is stiffer/stronger than the surrounding structure; therefore, earthquake loads transmitted within the shear walls will be concentrated in the area where the Hardy Frame was installed. As described above, this condition can lead to excessive structural damage surrounding the frame or to failure of the frame itself because the concentrated load may be greater than the load carrying capacity of the frame. Therefore, the Hardy Frame will not share the load with the existing structure when the structure is subjected to a force; therefore, the Hardy frame will act as an over-built wall.

Another available product is the pre-engineered STRONG-WALL® shear panel available from Simpson Strong Tie Company, Inc., Pleasanton, CA. The StrongWall® is constructed of standard framing materials and metal connectors. The StrongWall® further includes a plurality of devices configured to anchor the StrongWall® to a building foundation. Because the StrongWall® must be connected to the structures foundation this requires special work on the foundation prior to installation, thus making retrofit application of the StrongWall® difficult. In addition to that above, the StrongWall® is delivered to a job site as a pre-built panel, thus the architect must take into consideration shipping costs in addition to handling costs associated with the installation of these heavy

panels on the building site. The Strong-Wall® provides load values significantly higher than traditional shear walls. In other words, the Strong-Wall is stiffer/stronger than a traditional shearwall. A Strong-Wall® can reduce the amount of wall space required for shear walls. By installing a pre-fabricated panel, this allows a builder to continue building without requiring a special on-site building inspection. However, the Strong-Wall® suffers from principally the same limitations as described above with the Hardy Frame.

An additional key shortcoming of each of these devices is that they must be placed within a solid wall portion of the structure, and therefore, will not allow for entry and egress from the building at the point of installation.

Referring now to U.S. Patent No. 6,112,799 Mullet et al., there is shown a wind resistant sectional overhead door. The wind resistant sectional overhead door of Mullet et al. as shown and described in the above-referenced application is only capable of resisting wind forces that are perpendicular to the door. The sectional door resists the wind forces by utilizing tension rod assemblies that transfer the wind load from the door to the frame of the door. The sectional door of Mullet et al. is incapable of transferring in-plane shear and acting as a shear panel because load-carrying mechanisms are not provided for in the Mullet et al. design. Door edge shear cannot be sustained on any edge of the assembly; furthermore, the wind resistant door of Mullet et al. does not provide any restraint mechanism that will prevent the door from overturning when subjected to shear forces generated by an earthquake. Therefore, if the sectional door of Mullet et al. were to be subjected to shear forces the door would lift and rotate. Because the sectional door can freely rotate, the sectional door and track assemblies are incapable of acting as a shear panel to transfer forces therethrough.

By providing a device that can be disposed about an opening, thereby allowing the opening to behave in the same manner as a continuous shearwall, an architect/engineer is allowed more freedom in the design of the structure. This is possible because the openings formed within the shearwall absorb/dissipate/transmit forces in the same manner as a continuous shear panel and do not create substantial load concentrations within the shearwall or otherwise amplify stresses resulting from applied shear loads. Additionally, the device according to the present invention may be utilized during new construction; may be easily and economically adapted to retrofits; and does not impose restrictive requirements on the placement of openings. Furthermore, the device according to the present invention may be fabricated at an off-site location and then easily installed at the building site. The benefits of providing a pre-fabricated device will be described in greater detail below.

In the seismic design (or retrofitting) of a structure, it can be seen that a balance must be struck while providing the optimal shear characteristics of the respective building planes to provide the requisite shear resistance to prevent cumulative or excessive damage or collapse of the building. The proper structural rigidity must be provided while maintaining the desired level of ductility for energy dissipation. Unfortunately, practical design of typical dwelling structures includes structural discontinuities (e.g., windows, doors) that can undermine the load path within a structure. An obvious source of major structural discontinuity in many structures is a garage opening. As will be appreciated by one having ordinary skill in the art, the structural reinforcement system of the present invention provides a novel means of enhancing the structural integrity (i.e., rigidity and ductility) of single and multi-level buildings while providing entry and egress from the structure. The reinforcement system further enhances the wind load resistance in addition to providing increased security in the form of a reinforced movable panel and frame assembly.

In addition to the above, there is a need for a device that may be utilized to not only structurally reinforce the opening of a structure but to also increase the security of the opening. Conventional garage door assemblies do not provide much resistance to thieve's break-in attempts. Typically, a conventional garage door assembly, such as that shown in Mullet et al. can be easily dislodged from the tracks in which the door is disposed in by applying a force to the edge of the door. Once the door is dislodged from the tracks, unauthorized entry may then be made into the structure. Because current building practice dictates that more garages are being built attached to the structure there is a need for a reinforced assembly that will prevent unauthorized entry into the structure, thereby gaining direct access to the occupant's indoor living environment.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a structural reinforcement system for reinforcing an opening in a building, the structural reinforcement system comprising a frame defining an opening formed in a building, the building supported by a foundation, the frame comprising at least two substantially vertical members and at least one substantially horizontal member connected to the substantially vertical members. At least one channel member connected to one of the substantially vertical frame members, the channel member including a groove formed therein. A movable panel adapted to move between a non-shear force transmitting position and a shear force transmitting position, the movable panel comprising at least one panel member, the panel member including a groove engagement device disposed on opposing ends, the groove engagement device configured to be slidably received within said groove, and at least one panel-restraining device, the panel-restraining device configured to substantially restrain and secure the movable panel in the

shear force transmitting position when a force is applied to the frame. The movable panel and the channel member connected to the opening and being configured to provide a substantially continuous load path when the movable panel is disposed in the shear force transmitting position.

In accordance with the present invention there is also provided a structural reinforcement system for reinforcing a structure, the structural reinforcement system comprising a frame defining an opening formed within a structure, the frame including at least two substantially vertical spaced apart members and a substantially horizontal member connected to the two substantially vertical members. At least one first channel member connected to at least one of the substantially vertical frame members, at least one second channel member coupled to the first channel member and forming a groove therebetween. A moveable panel adapted to substantially close the opening when the panel is in a first position and substantially open the opening when the movable panel is in a second position, the movable panel comprising at least one panel member, the panel member including channel engagement members disposed on opposing ends, the channel engagement members being adapted to slidably engage the first and second channel members, and at least one panel-restraining device configured to substantially restrain the movable panel in the shear force transmitting position. The movable panel and the channel members being in communication with the opening and configured to provide a substantially continuous load path when the movable panel is disposed in the shear force transmitting position.

In accordance with the present invention there is further provided a device for providing security for an opening formed in a structure, the device comprising at least one first channel member, the first channel member coupled to a frame, the frame defining an

opening formed in a structure. At least one second channel member rigidly engaged to the first channel member. A reinforcing frame connected to the opening frame, where the reinforcing frame may or may not be coupled to the first and second channel members. A movable panel adapted to move between a first position wherein the opening is substantially open and a second position wherein the opening is substantially closed, the movable panel including a channel engaging member disposed on at least one end, the channel engagement member being adapted to be received by the first and second channel members. At least one panel-restraining for substantially restraining and securing the movable panel in the shear force transmitting position, wherein the frame reinforcement device is connected to the frame defining the opening. The movable panel and channel members are configured to provide a substantially continuous load path when the movable panel is disposed in the shear force transmitting position.

BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages will become apparent from the following and more particular description of the preferred embodiments of the invention, as illustrated in the accompanying drawings, and in which like referenced characters generally refer to the same parts or elements throughout the views, and in which:

FIGURE 1 is a schematic illustration of a panel subjected to shear loading;

FIGURE 2A is a schematic elevational view of a three-story building;

FIGURE 2B is an elevational view of a typical garage door opening;

FIGURE 3 is a rear elevational view of a prior art garage door system;

FIGURE 4 is a partial perspective view of the garage door system shown in FIGURE 3;

FIGURE 5 is a schematic elevational view of the building shown in FIGURE 2, illustrating the imminent collapse of the building proximate the garage structure of the building;

FIGURE 6 is a schematic elevational view of the garage structure shown in FIGURE 2, illustrating the applied forces to the structure;

FIGURE 7A is a partial perspective view of the structural reinforcement system according to the present invention;

FIGURE 7B is a partial perspective view of composite door panels according to the present invention;

FIGURE 8 is a partial section view of an additional embodiment of composite door panels according to the invention;

FIGURE 9 is a partial perspective view of a further embodiment of the structural reinforcement system of the invention;

FIGURE 10 is a partial section view of the embodiment of the invention shown in FIGURE 9, illustrating the engagement of the wheel assemblies and door panel engagement sections according to the invention;

FIGURE 11 is a partial section view of a first channel and a door panel, illustrating the slidable engagement of the panel within the first channel according to the present invention;

FIGURE 12A is a partial perspective view of reinforcement devices that may be disposed about the opening formed in the structure, wherein the reinforcement devices may or may not be coupled to the channels defining the reinforcement system according to the present invention;

FIGURE 12B is a plan view of another reinforcing frame disposed about an opening according to the present invention;

FIGURE 13 is an elevational view of another reinforcing frame disposed about an opening according to the present invention wherein the reinforcing frame is further coupled to the foundation and the channels defining the reinforcement system according to the present invention;

FIGURES 14 and 15 are partial elevational views of one embodiment of the panel securing means according to the invention;

FIGURE 16 is a partial perspective view of an additional embodiment of the panel securing means shown in FIGURES 14 and 15;

FIGURE 17 is a partial perspective view of a panel-restraining device according to the present invention;

FIGURE 18 is a rear elevational view of a panel-restraining device according to the present invention wherein the panel-restraining device is disposed in a locked position; and

FIGURE 19 is a partial perspective view of an exemplary alternative embodiment of the panel-restraining device according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The reinforcement system according to the present invention enhances the structural integrity of a structure to which the structural reinforcement system has been applied. Furthermore, the structural reinforcement system according to the present invention provides an effective moveable closure or barrier to increase the security of the structure. As a result, the system can be employed in a variety of applications, such as buildings (i.e., garage openings) to enhance earthquake and wind resistance as well as provide increased security. Each of the noted applications is discussed in detail below with reference to the FIGURES.

Referring now to FIGURE 2A, there is shown a schematic illustration of a three-story building 10 supported by a foundation 5. By the term “foundation”, as used herein, it is meant to include a body of material upon which a building stands, including, but not limited to, concrete, soil, gravel and mixtures thereof, grade beams and pile systems.

The building 10 includes two floors or living areas 13, 14, a plurality of windows 16, and a garage section 12. The garage section 12 includes two openings 12a, 12b to facilitate vehicle entry and egress as well as entry and egress for occupants, the openings 12a an 12b being defined by a frame.

Referring to FIGURE 2B, the opening 12a, which is similar to opening 12b of a conventional garage are defined by a frame, the frame including a header 25 and a pair of substantially vertical support members 26a, 26b. The vertical support members 26a, 26b are typically attached to the header 25 at one end, with the opposing end being in communication with the foundation 5. The support members 26a, 26b and header 25 are typically constructed of wood (e.g., plurality of wood beams). As illustrated in FIGURE 2B, the opening 12a of a conventional garage is typically disposed proximate the foundation 5. Thus, the present invention, discussed in detail below, is described in connection with a conventional garage opening 12a. However, as will be appreciated by one having ordinary skill in the art, the present invention is similarly applicable to raised building openings. Furthermore, the system according to the present invention may be disposed within other openings such as conventional doorways or window openings formed within a structure.

As illustrated in FIGURE 2A, the conventional garage section 12 also includes a moveable panel 15a, 15b, which are designed to provide an effective closure for the garage

openings 12a, 12b. The moveable panel 15a, 15b may comprise a solid panel (i.e., pivoting panel) or a multiple panel (i.e., "roll-up") system.

Referring to FIGURES 3 and 4, there is shown a conventional "roll-up" garage door system 30. The system 30 includes a plurality of interconnected panels 32, a plurality of panel hinges 33 adapted to hingedly connect mating pairs of panels 32, a plurality of guide wheels 34, a locking system 36, a locking system arm 36a, arm engagement members 35, a tensioning spring mechanism 37, and a pair of guide rails 38a, 38b. According to conventional construction practice, each guide rail 38a, 38b is secured via bolts to a respective support post (26a, 26b) and the ceiling structure (not shown) via support brackets 39a, 39b.

As illustrated in FIGURES 3 and 4, the guide wheels 34 are disposed on each end of the panels 32 and are adapted to rotatably and slidingly engage the guide rails 38a, 38b. During raising and lowering of the interconnected panels 32, the guide wheels 34 are positioned by the rails 38a, 38b to facilitate a smooth transition of the panels 32.

The system 30 of FIGURES 3 and 4, when closed, provides an effective closure of a garage opening. However, as will be appreciated by one skilled in the art, the conventional garage door system 30, described above, is not a structural member and thus provides no effective supplemental damping or stiffness (or shear and wind load resistance) to the building 10. Accordingly, the relative damping and stiffness of a building, such as building 10 illustrated in FIGURE 2A, will be dramatically different for the portion of the building defined by points A, B, E and F, denoted X, compared to the garage portion of the building

defined by points E, F, C and D (with or without the garage doors 15a, 15b in closed positions), denoted Y.

Thus, during an earthquake of any significant magnitude, structure Y can, and in many instances will, collapse about points C, D, E and F prior to any occurrence of significant structural damage to structure X (see FIGURE 5). The failure about points C, D, E and F is further enhanced by virtue of the downward force or load (denoted by arrows F_1, F_2 and F_3 in FIGURE 6) exerted by structure X on structure Y. As will be appreciated by one having ordinary skill in the art, upon any significant lateral movement of points E and F, relative to C and D, the downward force exerted by structure X would dramatically increase the internal moments at points C, D, E, and F.

The earthquake response characteristics of the building defined by structure X and Y will be dependent, in significant part, on the structural characteristics of the portion of the structure designated by Y in FIGURE 6. Improvements in the shear damping, stiffness and strength of the structure section Y will significantly enhance the earthquake resistance characteristics of the entire building.

Referring now to FIGURE 7A there is shown an exemplary embodiment of a preferred embodiment of an exemplary reinforcement system according to the present invention. As shown, the reinforcement system 80 comprises a moveable panel 170, a channel member 130c, a first panel securing means 160, and a second panel securing means 500. Each of the elements will be described below in greater detail with reference to the appropriate FIGURES.

Referring now to FIGURES 7B and 8 there is shown exemplary embodiments of reinforced shear panels in accordance with the present invention. Referring now to FIGURE 7B, the reinforced shear panel 100 includes a plurality of hingedly connected "composite" panels 102a-102b and a plurality of substantially elongated hinge assemblies 110, adapted to connect the panels 102a-102b. The panels 102a-102b further include a groove engagement device 136 (not shown) disposed on opposing ends. The panels 102a-102b may be constructed of various materials such as wood, steel, stainless steel, aluminum or engineered composites. It shall be understood the term "engineered composites" shall include materials such as carbon fiber, fiberglass, plastics, oriented strand board (OSB), engineered lumber, honeycomb or foam cores and similar materials.

In a preferred embodiment, each panel 102a-102b comprises a substantially honeycomb structure having an outer skin 104, a first core portion 108 proximate the hinge 110 and a second core portion 106.

According to the present invention, the skin 104 may be comprised of aluminum, steel, fiberglass or other like materials. The first core portion 108 and second core portion 106 may be comprised of foam, end grain balsa, corrugated cardboard or other like sandwich structure core material. In a preferred embodiment the first and second core portions 108, 106 are comprised of foam.

Referring now to FIGURE 8, there is shown an exemplary embodiment of an alternative embodiment of the shear panel in accordance with the present invention. As shown in FIGURE 8, the shear panel 100' may include interlocking means adapted to

rotatably secure the panels (e.g., 102a – 102b) in a substantially coincident plane when the panel 100 is in the closed position.

Referring to FIGURE 8, in a preferred embodiment the interlocking means includes a similar elongated hinge assembly 125 and an elongated hinge engagement member 124 (disposed on a first panel 120a) adapted to substantially engage the engagement chamber 126 on the adjoining (or adjacent) panel 120b. The panels 120a, 120b similarly may comprise a honeycomb or like structure, having an outer skin portion 128 and a core 129. In a preferred embodiment, the outer skin 128 comprises fiberglass and the core portion 129 is comprised of foam.

Referring now to FIGURES 9-15, there is shown another preferred exemplary embodiment of the reinforcement system in accordance with the present invention. As shown, the reinforcement system comprises a movable shear panel, at least two channels adapted to slidably receive the movable shear panel, and at least one panel securing device. The reinforcement system according to the present invention may further include a reinforcement frame disposed about the periphery or within the opening, wherein the reinforcement frame is operatively coupled to the channels and the panel-restraining device. It is further contemplated that the reinforcement frame may not be operatively coupled to the reinforcement system, thereby allowing the two elements to function independently.

Referring to FIGURES 9, 11 and 12, there is shown a first channel 130a and a second channel 130b, whereby the first and second channels form a groove 131 therebetween. According to the present invention, the channels 130a, 130b are attached to the vertical support members 26a, 26b that define the opening 12a formed in the structure. The channels

may be attached to the vertical support members via bolts through holes 133 or through the use of other fastening devices such as adhesives, nails, or similar devices.

Referring to FIGURE 10, there is illustrated a cross-sectional view of a guide wheel assembly 135'. As illustrated in Figure 10, the guide wheel assembly 135' includes a guide wheel 135, the guide wheel 135 is rotatably attached to a guide wheel channel 135". As illustrated in Figure 10, the guide wheel 135 is configured to engage the edge of the movable panel. The guide wheel channel is configured to extend from the upper portion of the second channel member 130b and to provide support of the movable panel when the movable panel is moved from a closed position to an open position, the guide wheel channel being disposed in a position substantially perpendicular to the movable panel. This can be better understood with reference to prior art FIGURE 4, wherein there is illustrated a conventional garage door assembly. As shown in FIGURE 4, a plurality of rollers 34 are disposed within a track assembly 34', wherein a portion of the track assembly is disposed substantially vertical and adjacent to the opening and a portion of the track assembly is disposed substantially perpendicular to the movable panels 32.

As will be appreciated by one having ordinary skill in the art, the channels 130a, 130b can also be employed with a conventional garage door or panel such as that shown in FIGURE 4, in order to provide structural reinforcement thereto in accordance with the present invention. Furthermore, the channels may be further adapted to receive a solid panel member, wherein the solid panel member is pivotally attached to the channels thereby allowing the panel member to be moved between and opened position and a closed position.

As illustrated in FIGURE 11, the first channel 130a includes a substantially U-shaped portion 134 adapted to slideably engage the correspondingly shaped panel engagement portion or section 136 disposed on each end of the movable shear panel 140. The first channel 130a further includes mounting holes 133 adapted to receive bolts. The first channel 130a is further adapted to receive the second channel 130b thereby forming a groove 131 therebetween, wherein the movable shear panel is received and retained within the groove 131 by the channels and the groove engagement device of the movable panel. The movable shear panel 140 may comprise a composite structure having a core 140a and outer skins 140b, with the groove engagement device 136 attached to each end thereof by conventional means. The groove engagement device 136 may be constructed of a non-pliable material such as aluminum, wood, steel, stainless steel, composite materials, plastics, or similar materials. In additional envisioned embodiments, not shown, the panels 140 comprise substantially solid members constructed of materials such as wood, aluminum, steel, engineered composites, or similar materials.

It is further contemplated that the first and second channel members as illustrated in Figure 11 may be formed as an integrated piece (not shown). That is, instead of being formed of two separate pieces that are then coupled together, the channels may be formed as a single channel, or as a unitary member, using known manufacturing methods such as extrusion, casting, pressing, or similar manufacturing methods which will produce a unitary member including a groove formed therein. By forming the two channel members as an integrated channel member allows for the production of a stronger, and lighter channel member. Furthermore, the unitary channel member may reduce the overall cost of the reinforcement system according to the present invention because the unitary channel member does not require additional assembly steps.

The first channel 130a may further include a "panel guide" 138 as shown in FIGURE 11. The panel guide may be constructed of a pliable material such that the panel guide acts to reduce the amount of friction between the engagement portion of the movable shear panel when the panel is moved between an opened position and a closed position. Further still, the panel guide may be configured to provide a weather tight seal between the channel members and the movable shear panel. The panel guide 138 is preferably fabricated of extruded ultra high molecular weight (UHMW) polyethylene or like material, and is secured in the channel 134 by mechanical devices or through the use of conventional bonding methods and devices.

Referring now to FIGURES 12A, 12B and 13, there are shown various embodiments of frame reinforcements that may be utilized with the reinforcement system according to the present invention. As shown in FIGURE 12A, the upper frame reinforcement device 137a and lower frame reinforcement device 137b are configured to reinforce the opening formed in the structure. The upper frame reinforcement devices are preferably attached to the frame structure 20 proximate the adjoining ends of the vertical supports 26a, 26b and header 25. The lower frame reinforcement devices 137b are preferably attached to the frame structure 20 proximate the lower ends of the vertical supports 26a, 26b and the sill plate. According to the invention, the frame reinforcement devices 137a, 137b can be attached to the frame structure 20 by conventional means. In a preferred embodiment, the frame reinforcement devices 137a, 137b are attached to the frame structure 20 via a plurality of bolts 139. It is further contemplated that the lower frame reinforcement device may be coupled to the foundation 5 of the structure through the use an anchoring device 137d. Still further, it is contemplated that an elongated reinforcement member (not shown) may be disposed between the ends of the upper and lower frame reinforcements thereby connecting the upper and lower frame

reinforcements. The elongated member may be affixed to the structure utilizing the above-mentioned methods and devices. Additionally, the ends of the elongated member may be affixed to the ends of the upper and lower reinforcement devices by welding. Alternatively, the elongated member may further include a flange disposed on each end, wherein the flange is configured to engage the ends of the upper or lower reinforcement devices.

Referring now to Figure 12B, there is shown an alternative embodiment of the upper reinforcement device 137a" in accordance with the present invention. As shown in Figure 12B, the upper reinforcement member 137a" is configured to extend across the header 20 of the opening 15. It is further contemplated that the upper reinforcement device 137a" may be connected to the channel members in accordance with the present invention. Additionally, it is contemplated that the lower reinforcement devices 137b as described above may be utilized in combination with the upper reinforcement device 137a". Still further, it is contemplated that an elongated member may be disposed substantially vertically between the ends of the upper reinforcement member 137a" and 137b, thereby connecting the upper reinforcement member 137a" and the lower reinforcement member 137b.

Referring now to FIGURE 13 there is shown a preferred embodiment of the frame reinforcement device according to the present invention. As shown, the frame reinforcement device 137a' may be configured to be coupled together thereby forming a U-shaped frame disposed about the opening 12. Additionally, the frame reinforcement device 137a' is configured to be operatively coupled to at least one of the channel members of the reinforcement system according to the present invention. In addition to being coupled to at least one channel member, the frame reinforcement device 137a' may be further configured to be attached to the foundation 5 as shown in FIGURES 12A and 12B. The foundation

attachment 137d may comprise a bolt disposed within the foundation when the foundation was being formed, or if installed in a retrofit application, a hole may be drilled into a concrete foundation and an adhesive or friction fit may be utilized to anchor the bolt therein. The reinforcement frame 137a may further include a portion 137d adapted to receive the bolt embedded in the foundation, thereby coupling the entire reinforcement system to the opening 12 and the foundation 5.

Referring now to FIGURES 14 and 15, there is shown one embodiment of a panel-restraining device for the multi-panel shear panel according to the present invention. The panel-restraining device comprises a substantially vertical channel member 130c, at least one pivoting arm 162, and a panel-restraining device 160. The pivot arm 162 is rotatably attached to the channel member 130c on one end and rotatably attached to the panel-restraining device 160 at the other, thereby allowing the substantially vertical locking arm to move relative to the first channel member. According to the invention, the pivot arms 162 are positioned such that when the movable shear panel 140 is closed in the direction denoted by arrow C_L, the shear panel 140 contacts the panel-restraining device 160 at the foot portion, designated 160a (see FIGURE 14) which causes the pivot arm 162 to rotate in the direction denoted by arrow R_P. As the pivot arm 162 rotates, the panel-restraining device 160 exerts a force in the direction denoted by F_D against the shear panel 140. The shear panel is thus captured below the top opening frame member and is thereby restrained vertically.

As will be appreciated by one having skill in the art, the noted panel securing device may comprise a single pivot arm system or a dual pivot arm system disposed on opposing channels 130a, 130b, as shown in FIGURE 12, or on opposing vertical supports 26a, 26b. The panel securing device can also include a lock plate and conventional lock assembly (also

referred to as a second restraining device (not shown)) and, hence, be employed as the primary means of securing (i.e., locking) the garage shear panel 140.

The panel securing device 160 can also be employed with a conventional locking system 500, such as that shown in FIGURE 16. In this embodiment, the panel securing device 160, and the channel 130c includes a securing hole or slot 506. The securing slot/hole 506 is configured to receive the pin 165 of the conventional locking system 500 (second restraining device) when the shear panel 140 is in the closed positioned. In yet another embodiment of the invention, the conventional panel securing means may be semi-manual or electronically controlled.

Referring now to FIGURE 16, there is shown a conventional latch device 500 in accordance with the present invention. The latch device 500 includes a main housing, a latch pin slidably disposed within the main housing and extending therefrom and a biasing means configured to bias the pin. As shown in FIGURE 16, the main housing is fixedly attached to panel securing device 160, wherein the latch pin 504 extends through a slot or hole formed in the panel securing device 160 and is further configured to be received within slot 506 formed in the channel member 130c. The latch pin 504 can be spring biased in an outward direction, denoted by Arrow I, and include conventional manual release means (e.g., release cord 510) to disengage the pin 504 from the track lock port 506 and locking arm slot 165. The latch system 500 can also include conventional electronic actuation means (e.g., solenoid) to move the pin 504 in outward and inward directions for engagement and disengagement.

As will be appreciated by one having ordinary skill in the art, the panel securing device illustrated in FIGURE 16 serves three distinct functions: (1) secures the locking bar

160 in the engaged position, (2) secures the door 170 in the closed position and (3) secures the engagement of the various load and shear members to their respective mating components.

With reference to the embodiments of the invention shown in FIGURES 7A-16 there has been shown a structural reinforcing system for use with shear panel assemblies that are disposed within an opening 12 formed in a structure. Typically in more modern construction the shear panel (garage door) is not disposed within the opening of the structure but instead disposed slightly behind the opening and in communication with the back of the wall forming the structure. Referring now to FIGURES 17-19 there is shown an exemplary embodiment of a preferred embodiment of the structural reinforcement system according to the present invention. As shown in FIGURES 17-19, the structural reinforcement system according to the present invention may be configured to be utilized for more modern construction methods and techniques, though will function in the manner as described above. The structural reinforcement system may be constructed of materials such as steel, stainless steel, aluminum, titanium, or engineered materials such as composites, plastics, or a combination of materials. It shall be understood that the list above should be considered merely exemplary and should not be considered to be limiting in any manner.

Referring now to FIGURES 17, 18 and 19 there is shown an exemplary embodiment of the structural reinforcement system in accordance with a preferred embodiment of the present invention. As shown, the structural reinforcement system comprises a first channel member, a second channel member, the second channel member coupled to the first channel member, a movable panel slidably engaged with the channel members, a panel securing device. The channel members and movable panel will not be described with reference to

FIGURES 17-19 as they have been fully described in great detail above with reference to FIGURES 7A-16, and the channels and movable panel function in the manner described above. The panel-restraining device will be described in greater detail with reference to FIGURES 17, 18, and 19.

Referring now to FIGURES 17 and 18 there is shown an exemplary embodiment of the panel-restraining device in accordance with the present invention. The panel-restraining device comprises an actuator rod, a latch plate, actuator rod carriers and a means for rotating the actuator rod between and open non-engaged position and a closed, locked, position.

As shown in FIGURES 17 and 18, the panel-restraining device 300 comprises an actuator rod 340. The actuator rod 340 is disposed above the movable shear panel 170, the actuator rod being rotatably mounted to the header 305 disposed above the opening through a plurality of actuator rod carriers 320. The actuator rod 340 may have a length at least as great as the opening in which the movable shear panel is disposed within. In a preferred embodiment the actuator rod extends beyond the opening, on at least one side of the opening, a sufficient amount to enable the device 330 for locking/unlocking the panel-restraining device to be disposed adjacent the opening. The actuator rod 340 may in other instances have a length greater than the opening. As shown, more than one rod carrier may support the actuator rod 340, the rod carrier comprising a main housing having a rotatable member disposed therein, the rotatable member adapted to receive and support the actuator rod.

The latch plate 350 is configured to engage the movable shear panel, wherein the latch plate engages the movable shear panel when the header locking system is rotated into the locked position. When the latch plate 350 engages the movable panel 170, the panel-

restraining device 300 prevents the movable panel from being moved from a closed position to an open position. Although the panel-restraining device 300 is shown in FIGURES 17 and 18 having 2 or 3 latch plates it is contemplated that a plurality of latch plates may be utilized to retain the movable panel in a closed position, though a single latch plate disposed about the center of the movable panel may be sufficient to retain the movable panel in a closed position but may not provide a sufficient retaining force.

The actuator rod and latch plate may be constructed of materials such as aluminum, stainless steel, copper, brass, steel, engineered composites, or similar materials. In a preferred embodiment, the actuator rod and latch plate are constructed of steel. The latch plate being fixedly attached to the actuator rod utilizing known attachment methods such as welding, brazing, bolts, screws, adhesives, or other similar materials or processes which would enable the latch plate to be affixed to the actuator rod.

Referring now to FIGURE 19, there is shown an exemplary alternative embodiment of the header locking mechanism 400 in accordance with the present invention. The panel-restraining device 400 comprises an actuator rod, a latch plate, actuator rod carrier, and a means 430 for disposing the latch plate between an open unlocked position and a closed locked position.

The panel-restraining device 400 functions in the manner described above with regard to the panel-restraining device 300 shown in FIGURES 17 and 18. As shown in FIGURE 19, the latch plate 460 extends along the entire length of the movable shear panel 170. The panel-restraining device 300 or 400 prevents the movable panel from sliding up the tracks from a closed position to an open position when a force is applied to the movable panel or to

the building structure. In addition to retaining the movable panel from sliding up the channels, the panel-restraining device further applies a horizontal force to the top of the movable panel thereby retaining the movable panel against the header defining the opening. More specifically, the panel-restraining device prevents the door from overturning within the opening, thereby allowing the movable shear panel to transmit a shear load across the opening. The panel-restraining device 400 may further include a plurality of slots 425 formed therein, wherein the slots 425 are adapted to receive and retain pins 435. The pins 435 extend from the backside of the movable shear panel as shown. The engagement of the pins 435 within the slots 425 of the latch plate 460 further retains the top of the movable panel assembly from lateral (side-to-side) movement due to forces applied thereto.

The means for disposing the panel-restraining device 300 and 400 between an open unlocked position and a closed locked position may comprise a mechanical lever actuated rod system 430 such as that shown in FIGURE 19 or an electromechanical system, for example an electric motor 330 coupled to the actuator rod, such as that shown in FIGURE 17. It shall be understood that the means for disposing the panel-restraining device 300 and 400 between an open unlocked position and a closed locked position may be manually actuated after the movable shear panel has been moved from an open position to a closed position, or alternatively, in a preferred embodiment, the actuating means is coupled to the movement of the movable shear panel such that the panel-restraining device is engaged or disengaged when the movable panel is opened or closed, though, it shall be understood that the actuation means will not release the panel-restraining device when the movable panel is subjected to a shear force or perpendicular wind force wherein the forces may attempt to displace the movable panel from a closed position to an opened position. An example of an automated system would be to utilize an electric motor coupled to the actuator rod in addition to an appropriate

controller, wherein the motor and controller are coupled to an automatic door opening/closing device. Therefore, when the automatic door opening/closing device is activated, the electric motor would be activated to open or close the panel-restraining device accordingly. In any case of emergency or power failure, an electromechanically activated system shall be capable of manually disposing the panel-restraining device 300 and 400 between a closed locked position and an open unlocked position.

The panel-restraining device shown in FIGURES 17-19 may be utilized in combination with the reinforcement frame according to the present invention. Additionally, it is contemplated that the upper frame reinforcements and the lower frame reinforcements as shown in FIGURE 12 may be utilized in combination with the reinforcement frame and panel-restraining device in accordance with the present invention. Furthermore, it is contemplated that the upper frame reinforcement and lower frame reinforcement may be configured such that as installed they are coupled to one another thereby providing greater reinforcement about the opening formed in the building structure.

In use, the movable shear panel is moved from the second position to the first position. This may be through the use of an automatic closing device such as a conventional garage door opener/closer or may be manually operated or both. The first and second channel members guide and retain the edges of the movable panel member. The panel-retaining device is then moved into a locked position thereby retaining the movable shear panel in a closed position. At this time, if a force were applied to the building structure, such as an in-plane force applied by an earthquake, the force would be transmitted across the opening through the movable shear panel via the first and second channels disposed about the frame. Additionally, the panel-restraining device would retain the movable shear panel in a closed

first position thereby preventing the movable shear panel from overturning and securing the engagement of the various load and shear members to their respective mating components. The channels retain the movable panel within the groove formed therebetween, that is, the channels will retain the panel side-to-side within the opening as well as retain the panel from moving in an in-and-out or perpendicular direction. The channels rigidly retain the movable shear panel within the groove when the movable panel and/or structure are subjected to a force. The movable panel is configured to transmit forces thereacross and through the channels retaining the shear panel, wherein the force may then be absorbed/dissipated/transmitted by the remaining portions of the structure.

In addition to restraining the movable panel and further enhancing the load transmitting ability of the movable panel, the panel-restraining device of FIGURES 17-19 further acts to provide improved security of the opening by resisting any upward force that may be applied to the movable shear panel. Referring now to FIGURE 3 there is shown a conventional locking system utilized on a conventional garage door. As shown, the locking device is activated by a handle connected to the two locking devices, if a thief or intruder wishes to gain access to the structure, a hole could be cut adjacent the locking assembly whereby the levers could be activated independent of the locked rotating handle. This type of entry would not be possible with the present invention because the locking device is disposed about the top of the door assembly and cannot be easily disengaged by cutting a hole in the shear panel.

As will be appreciated by one having ordinary skill in the art, the reinforcement system according to the present invention provides increased security against forced break-in attempts. Unlike conventional garage doors that can be easily forced off the tracks, such as

that shown in FIGURE 3, the reinforcement system according to the present invention cannot be removed from the channels through the application of force to the shear panel assembly. If a force were to be applied to the movable shear panel, the force would be transmitted through the panel into the channel members engaged by the panel engagement members disposed on the ends of the panels. The channels of the reinforcement device according to the present invention are formed of material having sufficient strength to resist bending or breaking. The channels will retain the movable shear panel within the opening if a force is applied to the panel. This is unlike conventional garage door track hardware wherein the track assemblies are vulnerable to exterior tampering and are constructed of light gauge metals that bend and flex easily. Furthermore, because the shear panel is restrained in both vertical and horizontal movement any forces applied to the shear panel will be transmitted to the surrounding frame 12 and reinforcement members that are connected thereto.

To ensure that the structural reinforcement system is in closed position in the event of an earthquake, an automatic garage door-closing/opening device (not shown) can be incorporated into each noted system. In a preferred embodiment, the automatic closing means comprises a motion sensing device, such as an accelerometer or motion detector, which is operatively connected to a conventional electrically operated garage door opener system (not shown).

According to the invention, when the motion-sensing device receives an input reflecting a predetermined threshold value, the sensing means provides a first signal to the electric garage door system. In response to the first signal, the garage door system initiates the closure sequence to move the shear panel from an open position to a closed position. In

the event of a power failure, the automatic closing system is additionally provided with a back-up power source, such as a battery pack (not shown).

In an additional envisioned embodiment of the invention, the automatic closing means may further include a timing device and associated programming device to ensure that the shear panel is not left open for an extended period of time. According to the invention, the timing device could be configured to sound an alarm and/or automatically close the shear panel if left open for more than a fixed period of time.

Although the present invention has been described in detail with regard to resisting lateral or in-plane forces, as will be appreciated by one having ordinary skill in the art, the structural reinforcement system according to the present invention is also applicable to substantially horizontal perpendicular loads and/or rotational loads which may be applied to the structure.

Without departing from the spirit and scope of this invention, one of ordinary skill can make various changes and modifications to the invention to adapt it to various usages and conditions. As such, these changes and modifications are properly, equitably, and intended to be, within the full range of equivalence of the following claims.